

In-Situ Monitoring and Process Control (AMARU), Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

Made In Space, Inc. (MIS) is a global leader in manufacturing technologies for harsh environments. MIS developed, owns and operates a commercial Additive Manufacturing Facility (AMF) aboard the International Space Station (ISS), used for both government and commercial use. Over multiple years of operation, MIS developed quality processes that ensure the success of printing in the microgravity environment which is operated and monitored from the ground control station at MIS' Moffett Field facility. These processes include ground testing, computer modeling, and simulations of the final product to optimize manufacturing on orbit. These quality processes are key to the successful operation of AMF.

MIS continues to break new ground: recent successes include an Optical Fiber EXPRESS Rack payload, the first operation of polymer additive manufacturing in a simulated Low Earth Orbit environment, and a Guinness Book of World Records award for longest 3D printed structure.

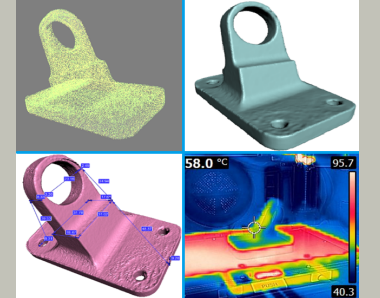
But why stop there? MIS has been researching metal additive manufacturing since its founding. The Vulcan Phase I SBIR Technology Development Program (TDP) combines metal additive manufacturing with traditional manufacturing methods, enabling components to be produced in gravity independent environments.

In developing these various manufacturing technologies, MIS has extensively researched new Verification and Validation (V&V) methods to confirm fabricated components meet the rigorous standards required for aerospace applications. Building on the successes of AMF and SAMEE, a DARPA funded SBIR Phase I TDP (Section 5), AMARU would enhance the state of the art V&V methods by combining and integrating advanced sensor technology and Siemens' industry leading NX software tools.

Anticipated Benefits

NASA is currently undergoing the Phase A of the Fabrication Laboratory (FabLab) under the NextSTEP program which involves developing a universal manufacturing machine capable of using multiple materials but is also required to have an extensive validation and verification system for quality control. MIS would develop this hardware and software suite to be proposed on future Phases of FabLab and could offer AMARU as an add-on to other manufacturing systems being developed for this program.

There are many companies that can use AMARU in the additive manufacturing, subtractive manufacturing, and assembly line markets. Because AMARU is universal and requires little space near the build volume, the system can be integrated in a variety of ways with little to no interference. However, this system provides a robust set of data monitoring and feedback control to increase throughput, decrease waste and provide an overall increase in both



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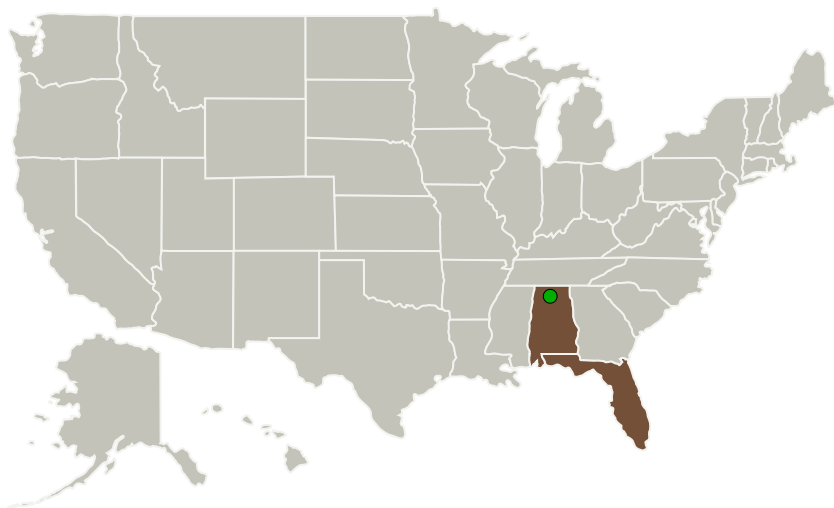
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accuracy and precision of each manufactured part.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Made in Space, Inc.	Lead Organization	Industry	JACKSONVILLE, Florida
● Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations

Alabama	Florida
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Project Transitions

▶ **July 2018:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Made in Space, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

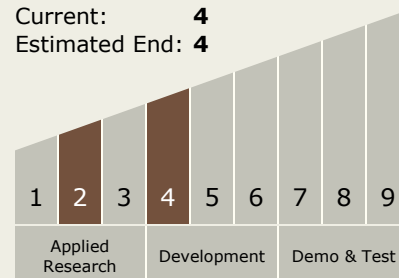
Carlos Torrez

Principal Investigator:

Michael Snyder

Technology Maturity (TRL)

Start: 2
Current: 4
Estimated End: 4



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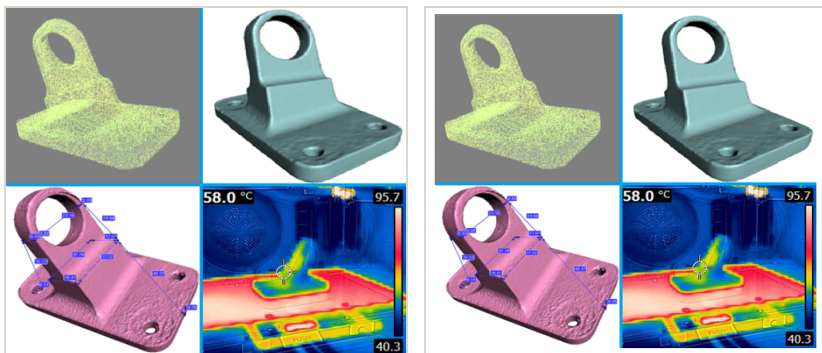


✓ **February 2019:** Closed out

Closeout Documentation:

- Final Summary Chart(<https://techport.nasa.gov/file/141828>)

Images



Briefing Chart Image

In-Situ Monitoring and Process Control (AMARU), Phase I
(<https://techport.nasa.gov/image/129912>)

Final Summary Chart Image

In-Situ Monitoring and Process Control (AMARU), Phase I
(<https://techport.nasa.gov/image/132776>)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - └ TX12.4 Manufacturing
 - └ TX12.4.1 Manufacturing Processes

Target Destination

Earth